# BIOMETHANATION OF SEWAGE WASTEWATER USING ULTRASONIC MEMBRANE ANAEROBIC SYSTEM (UMAS)

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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# ABSTRAK

Air kumbahan kumbahan adalah air kumbahan keras yang mengandungi permintaan oksigen kimia (COD), permintaan oksigen biologi (BOD), pepejal terampai (TSS) dan pepejal terampai (VSS) yang tidak menentu. Parameter penting ini perlu dirawat terlebih dahulu sebelum ia dilepaskan ke mana-mana laluan air. Terdapat banyak kaedah rawatan yang tersirat sehingga dekad ini dengan pendekatan tradisional. Sistem kolam adalah kaedah paling tersirat kerana kosnya yang rendah. Air buangan kumbahan merawat untuk menghasilkan gas metana dengan menggunakan kaedah pencernaan anaerobik membran. Tetapi akan ada masalah membran membran yang disebabkan oleh sejumlah besar jumlah pepejal yang dibawa oleh air kumbahan. Oleh itu kos operasi loji rawatan itu akan sangat tinggi. Oleh itu, Sistem Membran Anaerobik Ultrasonik (UMAS) digunakan sebagai kaedah alternatif untuk mengatasi masalah ini. Sisa air kumbahan dikumpul dari Kuantan Water Indah dan menyesuaikan diri selama 5 hari sebelum menjalankan reaktor. Barisan air sisa baris direkodkan, COD adalah 164.67 mg / L, dan BOD adalah 17.4 mg / L, dan TSS adalah 31 mg / L, dan VSS adalah 6mg / L, pH, tekanan dan suhu sentiasa berterusan semasa eksperimen dalam nilai 6.5 hingga 7.5, 2 hingga 3 bar dan 35 hingga 46 ºC masing-masing. Prestasi Sistem Membran Anaerobik Ultrasonik UMAS dinilai berdasarkan keupayaan (UMAS) untuk merawat parameter ini. UMAS mesti dikendalikan setiap hari selama 5 jam operasi sehari. Percubaan dilakukan apabila UMAS mencapai keadaan mantap. Keadaan mantap dicapai pada hari 5. Prestasi UMAS menunjukkan kecekapan penyingkiran COD yang tinggi dengan 97.4%. dan kecekapan penyingkiran BOD dengan 92%, kecekapan penyingkiran TSS 97% dan kecekapan penyingkiran VSS 99% dan komposisi gas metana yang diperolehi adalah kira-kira 79%. Berdasarkan hasil yang diperoleh selepas sepuluh hari percubaan menunjukkan UMAS dapat merawat kekuatan dan air sisa yang rendah, tanpa masalah pengotoran membran dan menghasilkan gas metana dari air sisa kumbahan. Selain itu, kerja selanjutnya diperlukan untuk memberikan pemahaman yang lebih mendalam tentang mekanisme yang terlibat untuk memudahkan pembangunan sistem optimum yang digunakan untuk bidang loji rawatan air sisa.

# ABSTRACT

Sewage wastewater is hard wastewater that contains a high amount of chemical oxygen demand (COD), biological oxygen demand (BOD), total suspended solids (TSS) and volatile suspended solids (VSS). These vital parameters should be treated first before it is discharged into any waterways. There are many treatment methods implied until this decade with the traditional approach. Pond system is the most implied method due to its low cost. The sewage wastewater was treating to produce methane gas by using membrane anaerobic digestion method. But there will be membrane fouling problem caused by high amounts of total solids carried by the wastewater. Therefore the operating cost of the treatment plant it will be very high. Thus, Ultrasonic Membrane Anaerobic System (UMAS) is used as an alternative method to overcome this problem. The sewage wastewater was collected from Kuantan Water Indah and acclimatizing for 5 days before running the reactor, The row wastewater parameter was recorded, COD was 164.67 mg/L, and BOD was 17.4 mg/L, and TSS was 31 mg/L, and VSS was 6mg/L, the pH, pressure and temperature was kept being constant during the experiment within the values of 6.5 to 7.5, 2 to 3 bar and 35 to 46 ºC respectively. The performance of Ultrasonic Membrane Anaerobic System UMAS is evaluated on the ability of (UMAS) to treat these parameters. The UMAS must be operated daily for 5 hours operation per day. The experiment is done when the UMAS is achieving a steady state. The steady state is achieved on day 5. The performance of UMAS showed high COD removal efficiency with 97.4%. and BOD removal efficiency with 92%, TSS removal efficiency 97% and VSS removal efficiency 99% and the methane gas composition obtained was about 79%. Based on the result obtained after ten days of the experiment shows that UMAS can treat strength and low wastewater, with no membrane fouling problem and produce methane gas from sewage wastewater. Moreover, further works are required to provide more in-depth understanding of the mechanisms involved to facilitate the development of an optimum system applicable to the field of the wastewater treatment plant.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AD | Anaerobic digestion |
| BOD | Biochemical oxygen demand |
| $CH_4$ | Methane gas |
| COD | Chemical oxygen demand |
| HRT | Hydraulic retention time |
| MAS | Membrane anaerobic system |
| TSS | Total suspended solids |
| UMAS | Ultrasonic membrane anaerobic system |
| VSS | Volatile suspended solids |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Water is essential for life as it is one of the most critical natural resources on the planet. Wastewater, which is primarily used water, is also a valuable resource, especially with recurring droughts and water shortages in many areas in the world. However, wastewater contains many harmful substances and cannot be released back into the environment until it is treated. Thus, the importance of wastewater treatment is to restore the water supply and prevent the environment from pollution and temperature rising and to protect the planet from toxins. There are several types of wastewater produced every day in Malaysia like sewage wastewater and palm oil mill effluent (POME) wastewater, sugarcane wastewater, slaughter wastewater, brewery wastewater. Before treatment processes begin, the values of chemical oxygen demand (COD) and biological oxygen demand (BOD) of any wastewater should be examined and compared it to stander A and stander B according to the Department of Environmental (DOE). If the value of COD and BOD are greater than stander A and stander B, then treatment of wastewater should be taken compulsorily. Wwastewaters treatment plants require a large area and sophisticated treatment process, and their operational cost will be extremely very high (Tiruneh *et al.,* 2014).

Malaysia has a population of 28.3 million based on the Report of Census 2010 by the Department of Statistics. The estimated volume of wastewater generated by municipal and industrial sectors is 2.97 billion cubic meters per year (Mat et al., 2013). The generation of municipal sewage wastewater is increasing every day in Malaysia. The municipal sector is consuming a large volume of water from natural water resources, and consequently generates a considerable amount of wastewater discharge. Municipal sewage, which contains both domestic and industrial wastewater, may differ from place to place depending upon the type of industries and industrial establishment (Iit and Kharagpur, 2000). Sewage wastewater is 99% water, and the rest is containing ions. Sewer is a mixture of water, and water carried wastes originating from homes, industrial facilities and commercial. Sewage wastewater is a major carrier of disease (from human wastes) and toxins (from industrial wastes). Untreated wastewater mainly contains high levels of organic material, numerous pathogenic microorganisms and nutrients and toxic compounds. The pollutant wastewater can cause many problems of pollution thus the safe treatment of sewage it is essential to the health of any community.

An understanding of the nature of wastewater is fundamental for the design of appropriate wastewater treatment plants and the selection of effective treatment technologies. Anaerobic digestion is the most suitable method to treat sewage wastewater. High-rate anaerobic bioreactors have shown better treatment efficiency, and they are producing better-treated effluent with shorter retention times, these anaerobic bioreactors also require less space, as well as greater methane production. Anaerobic digestion happens in the absence of air (and thus molecular/free oxygen) by those microorganisms (also called anaerobes) which do not require air (molecular/free oxygen) to assimilate organic impurities. The final products of biological assimilation in anaerobic treatment are methane and carbon dioxide gas and biomass (Mittal, 2011). Utilizing anaerobic digestion technologies reduce the emission of landfill gas into atmosphere and emission greenhouse gasses and it can replace energy derived from fossil fuels and widely used as a source of renewable energy. Anaerobic digestion is an efficient wastewater treatment technology that harnesses natural anaerobic decomposition to reduce waste volume and generate biogas at the same time. It has been widely applied to the treatment of wastewater from agricultural and industrial operations. Anaerobic digestion has been touted as the best process for the treating of sewage wastewater than other treatment types.

## 1.2 Problem Statement

With growing concerns over climate change associated with fossil-fuel utilisation, anaerobic treatment of the sewage wastewaters receiving increased attention (Tiruneh *et al.*, 2014). Now a day, the anaerobic treatment system for treating the sewage wastewater before discharging into rivers and other water sources is meager cost. But the biogases emitted during biodegradation of swage wastewater will be released into the atmosphere. These biogases especially methane gas has high potential to cause global warming and greenhouse effect.

Moreover, anaerobic treatment system requires a large area and has long hydraulic retention time (HRT) (Poh P.E, 2009). Membrane anaerobic system (MAS) can be used to treat the sewage wastewater but there will be membrane fouling problem caused by high amounts of total solids carried by the wastewater. The total suspended solids can reduce the membrane permeability and slow down the flow and decrease membranes performance and the quality of the water will be affected by severe flux declined will take place when the membrane fouling being occurs. To overcome this problem, the membrane can be taken out and cleaned using chemical cleaning method, but that solution will increase the operating cost of the treatment plant. The membrane can be suffered from fouling and degradation during it is continuous usage. Therefore another solution and more economical to overcome this problem, is adding ultrasonic device into the (MAS) system in treating POME wastewater and producing methane (Abdulrahman, 2014). However there is some development to be upgraded to improve the Ultrasonic Membrane Anaerobic System (UMAS) to produce the methane from sewage wastewater.

## 1.3 Research Objectives

The following objectives were considered in this research

i. To evaluate the performance of Ultrasonic Membrane Anaerobic System (UMAS) in treating sewage wastewater.
ii. To evaluate the retention time to the respective parameter (BOD, COD, TSS, VSS, PH).
iii. To produce methane gas from sewage wastewater.

## 1.4 Scope of Study

In this study, four scopes were considered in in order to fulfil the research objectives.

i. To design a laboratory scale ultrasonic membrane anaerobic system (UMAS) with an effective 100 litre volume to treat sewage wastewater.

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